Simulation of Closed Loop Buck Converter

Name : Akash Vishwakarma **Roll No. : 224102101**

1 Objective:

Design PCB of closed loop Buck converter and simulate it. The specifications for the buck converter are given below:

Sr.No.	Parameters	Value
1	Input Voltage	24V
2	Inductor	50μ H
3	Capacitor	100μ F
4	load Resistance	2 Ω
5	Switching Frequency	100kHz
6	Desired Gain Cross over Frequency	300Hz
7	Desired Phase margin	120°

Tabel 1: Input Parameters

2 Theory:

2.1 Duty Ratio:

Duty ratio represent the relation of input and putput voltage:

$$D = \frac{V_{in}}{V_o} \tag{1}$$

2.2 Transfer function

After performing small signal analysis function of the Buck converter we can easily get transfer:

$$G_p(s) = \frac{V_o(s)}{d(s)} = \frac{V_{in}}{LCs^2 + \frac{L}{R}s + 1} \tag{2}$$

3 Compensator Design:

For designing of compensator first we calculate phase and gain of the transfer function at desired gain crossover frequency.

$$\phi_p = \angle G_p(j\omega)|_{\omega=\omega_c} = -2.77^\circ$$

$$\phi_b = \phi_m - \phi_p - 90$$

$$\phi_b = 120 - (-2.77) - 90$$

$$\phi_b = 32.77^\circ$$

Here ϕ_b is less than 90° so, we will go for type-2 compensator. Transfer function for the type -2 compensator is-

$$G_c(j\omega) = G_{MB} * \frac{(1 + \frac{\omega_z}{j\omega_c})}{(1 + \frac{j\omega}{\omega_p})}$$

Calculation for the compensator parameters-

$$k = tan(45^\circ + \phi_b/2) = 1.833$$

$$\omega_z = \frac{\omega_c}{k} = 1028.34 rad./sec$$

$$\omega_p = k * \omega_c = 3455.123 rad./sec$$

$$G_{MB} = \frac{1}{|G_p(j\omega_c|} = \frac{1}{24.55}$$

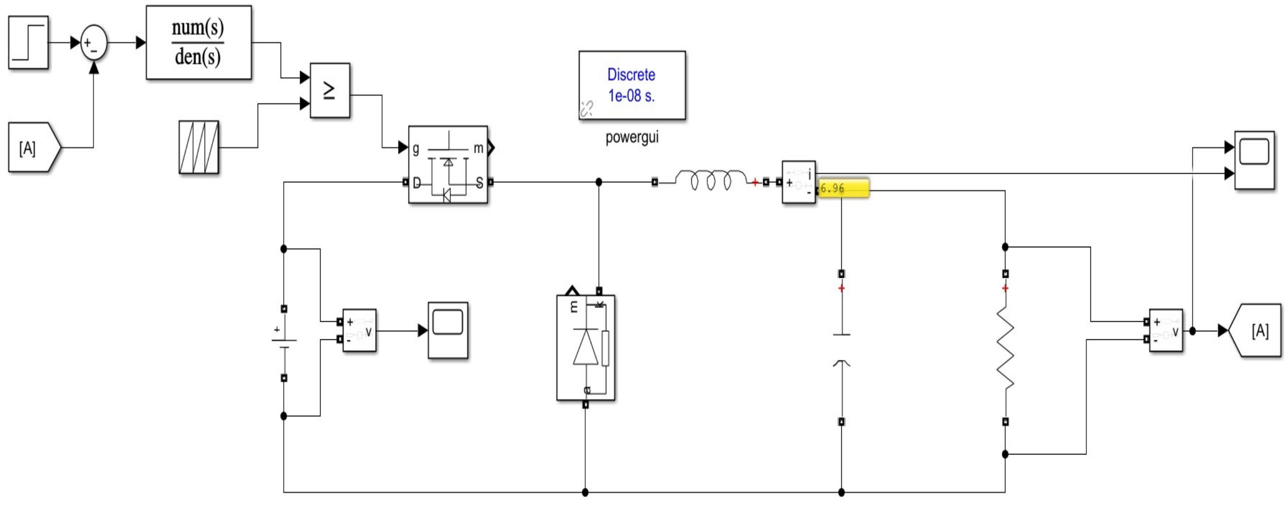
So finally the compensator is-

$$G_c = \frac{140.7s + 1.48e5}{s^2 + 3455s}$$

MATLAB code for compensator is-

```
clc
clear all
close all
Vs=24; L=50e-6; C=100e-6; R=2;
x=[Vs];
y=[L*C L/R 1];
G_p=tf(x,y)
bode(G_p)
grid on
%margin(G_p)
hold on
xc=[1 1028.34];
yc=[1 3455.123 0];
G_c=(3455.123/24.55)*tf(xc,yc)          %Compensator design
bode(G_c*G_p)
grid on
margin(G_c*G_p)
hold on
```

3.1 Simulation model of Buck Converter:



4 Waveforms and Results:

Bode plot of the compensated (closed loop buck converter) and uncompensated (open loop buck converter) is showing in red and blue colour respectively. Compensated system gives the phase margin 120° at the desired frequency 300Hz.

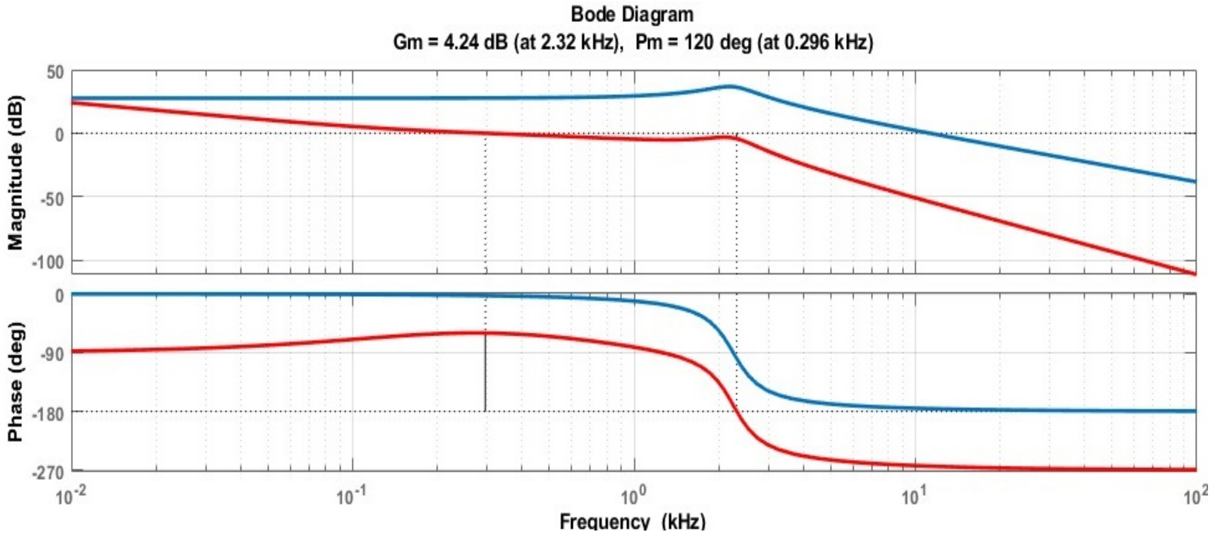


Fig. 1: Bode plot of compensated and uncompensated converter

By seeing the below waveforms we are giving inital reference signal 10V which is followed by output and giving step at 0.05 sec. to 15V again followed by the output of the converter.

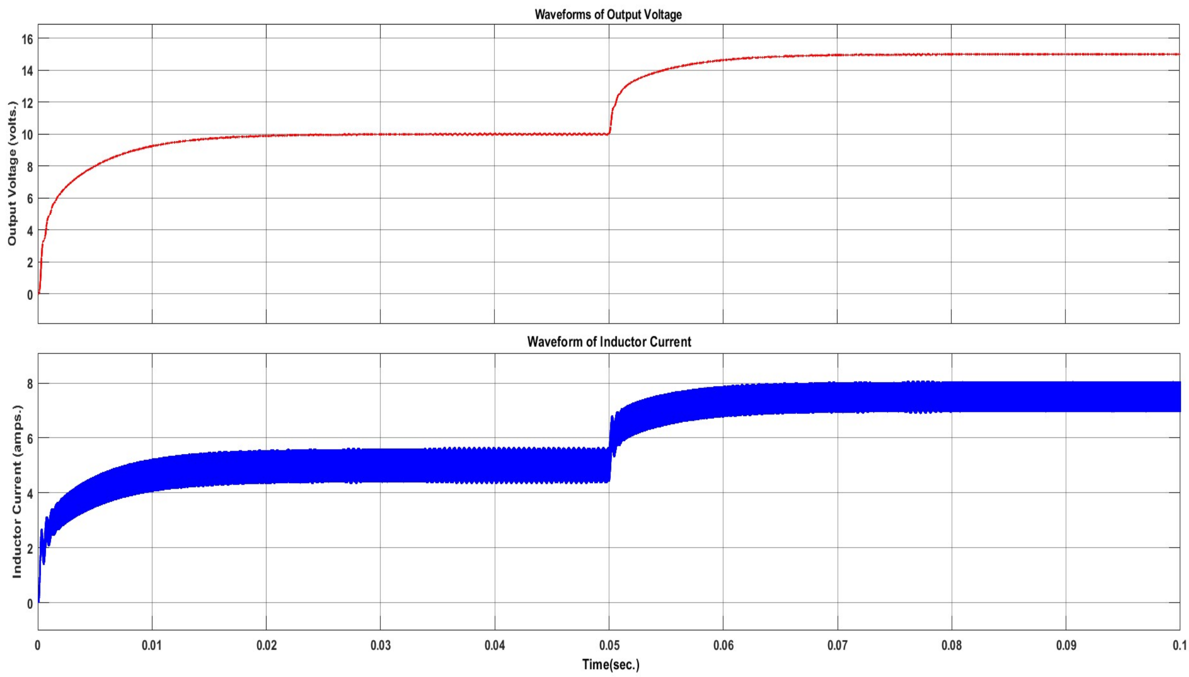


Fig. 2: Waveforms of output voltage and inductor current

5 PCB Model:

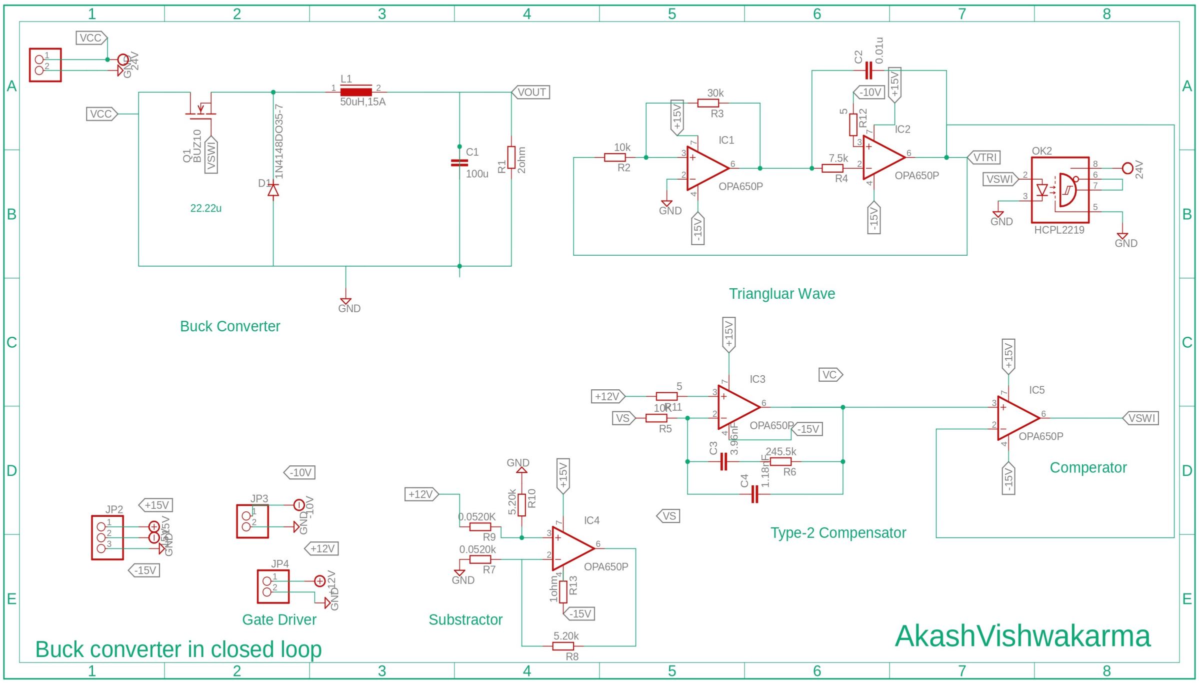


Fig. 3: Schematic diagram of PCB

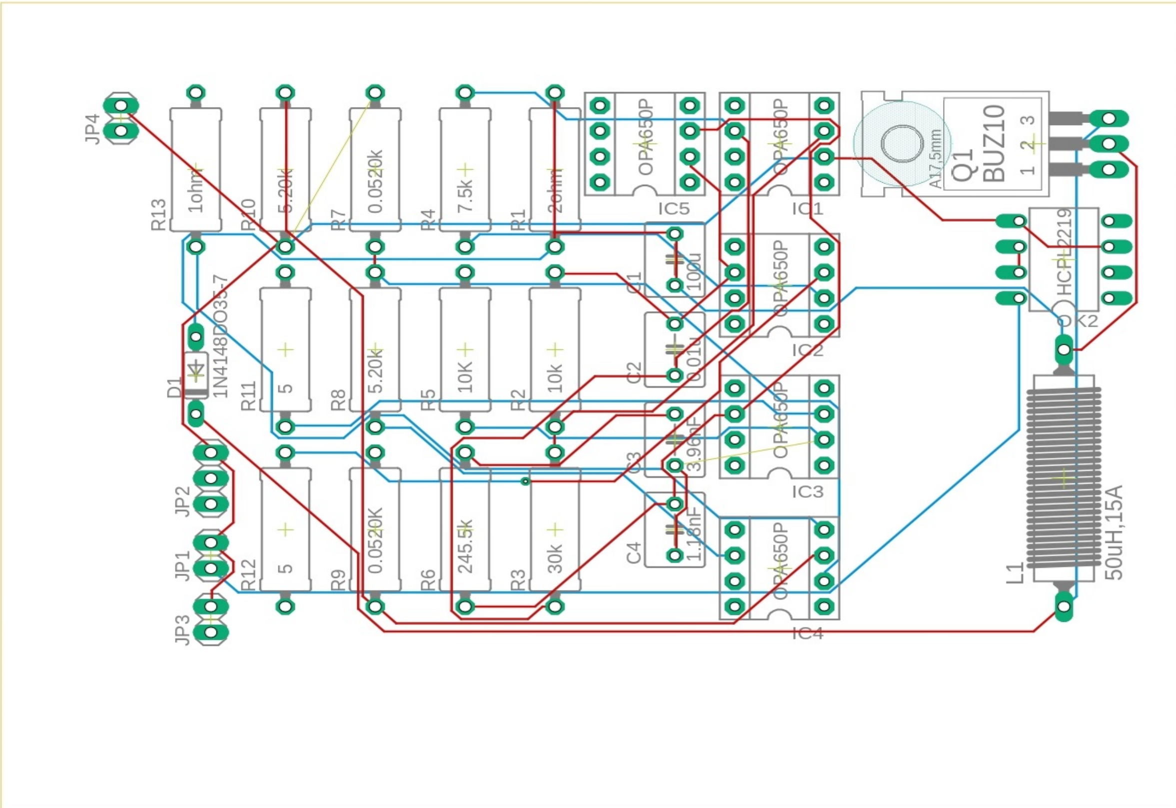


Fig. 4: PCB board Model